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INDEX TO VOLS. VII-IX

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AUTHOR INDEX

VOLS. VII-IX

SUBJECT INDEX

VOLS. VII-IX

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REVIEWS AND ABSTRACTS

In this section of the N.A.A.S. Quarterly Review, it is intended to survey current research and experiment in agriculture, horticulture and the allied sciences applicable to the work of the National Agricultural Advisory Service. It will not be possible, of course, to cover more than a small part of this wide field in each issue.

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Seasonal Variations in the Nutritive Value of Grassland Herbage

J. L. CORBETT

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THE MAJOR SEASONAL CHANGES in the nutritive value of grassland herbage are those associated with maturation of the plant. They have been studied in detail by Fagan and his associates at Aberystwyth, and Woodman and his associates at Cambridge. As physiological age increases there is a rapid decline in protein content and a marked fall in energy value due mainly to the increasing proportions of plant structural constituents. Consequently, to obtain maximum yields of easily-digested, nutritious herbage, the sward must be maintained in a leafy condition, and this is usually best achieved by a system where close grazing or cutting alternates with suitable rest periods when fertilizers are applied. This review will deal with seasonal changes in the composition of herbage produced by such management. In order to assess the nutritional significance of the changes, some discussion of the physiology of grazing animals is necessary; the references listed may be consulted for a fuller discussion.

Spring and Autumn Grass

It is widely believed that autumn grass has poorer feeding value than spring grass though gross chemical composition may apparently be similar or even in favour of the former. The apparent difference in feeding value is most often noticed when a high protein autumn grass fails to sustain milk production at its expected level. This problem has been studied by artificially drying herbage of similar origin and protein content at the two different times of year and feeding the products indoors under controlled experimental conditions. Dijkstra [1] in the Netherlands found no great differences in digestibilities using sheep, and neither he nor Holmes [2] found any significant differences in yields of milk, butterfat or solids-not-fat when the dried grasses were fed to dairy cows as the whole or part of their production ration.

Feeding the two types of grass simultaneously naturally eliminates many direct effects on the animals of differences between seasons in such factors as day-length, rainfall and temperature. These may be important. Brody [3], for example, devotes a whole chapter of his book "Bioenergetics and Growth" to seasonal rhythms in various metabolic activities in animals. Two findings of especial interest may be noted here. Raymond, Harris and Kemp [4] observed an apparent seasonal fluctuation in ruminant digestive ability, and Moir [5] found considerable seasonal variations in the total number of micro-organisms in the rumen of grazing sheep and in the relative proportions of individual

organisms. Other effects of season on grazing animals, though perhaps more indirect, are probably important. Autumn grass frequently has a rather high moisture content, intrinsically and because of surface moisture, and this may reduce the dry matter intake of grazing animals in the same way as has been observed with silage [6 and 7]. In addition, ungrazed residues and coarse clumps of herbage will tend to accumulate as the season progresses and lower the feeding value and palatability of the pasture as a whole. Palatability may also be reduced because of contaminating soil splashed by heavy autumn rains.

There are chemical differences between leafy spring and autumn herbages which would probably not be detected by the usual methods of feedingstuffs analysis.

PROTEIN

In work carried out before the war at the Hannah Dairy Research Institute, Morris and his associates [8] found that the protein of spring grass was apparently markedly superior to that of autumn grass in nutritive value for milk production. The difference was interpreted in terms of amino-acid composition, particular stress being laid on lysine content. At this time, however, rumen function was imperfectly understood. The two types of grass were fed with quantities of other feeds and these would have had considerable effects on the fate of nitrogen in the rumen and on the resulting N-balance data. Because of the microbial activity in the rumen differences in the amino-acid composition of feed protein are less important for ruminants than for monogastric animals; protein value depends far more on such characteristics as solubility and susceptibility to bacterial proteases, and on the amounts of carbohydrate, particularly starch, in the ration [9]. Chalmers and Synge [10] reviewing the whole of Morris's work in which many different sources of protein were fed, were more inclined to attribute the differences found to variation in the rate of microbial attack than to lysine content. Indeed, analyses of grass proteins [11, 12 and 13] have shown that these have a remarkably constant amino-acid composition both from season to season and at different stages of growth. In addition, it is unlikely that changes in the botanical composition of the sward with season would affect herbage protein quality to an appreciable extent since differences between species also appear to be small [14].

Dijkstra [15] has presented regression equations which, at any given crude protein level, appear to set the D.C.P. content of autumn herbage 0.6 units lower than that of spring material. But this comparison is invalid as the two sets of data used in calculating the equations did not overlap, the crude protein contents of the spring herbages being within the range 11-20 per cent and of the autumn herbages 22-28 per cent (all values expressed on an organic matter basis). Herbage crude protein levels frequently are at their maximum during the autumn

growth flush when the environment does not provide the conditions under which the grass plant produces seed [16]. This seasonal fluctuation may, however, be offset by the presence of a high proportion of clover in the sward, for the protein content of clover remains relatively constant [17].

Between 10 and 30 per cent of the nitrogen of herbage may be in non-protein form (N-P.N.), the major part of this fraction consisting of amino-acids and other substances concerned in the synthesis in the plant of protein from inorganic N. Consequently, N-P.N. as well as total N tends to be higher in more favourable growth conditions whilst as growth progresses to maturity so the N-P.N. percentage in herbage dry matter falls [18]. Analyses of herbage samples taken [19] from a mixed-species pasture whenever the regrowth after cutting reached a height of approximately 10 in., showed that total N-P.N., amino-N and amide plus NH_3-N levels tended, in general, to be highest in early and late summer. Nitrate N was present in the largest amounts from August-October following applications of 4-6 cwt "Nitro-Chalk" per acre, the maximum value being 0.52 per cent nitrate in the herbage dry matter. So high a level might endanger the health of grazing animals [20 and 21]. Synge [22] points out that organically combined-N-P.N. substances are probably the most reactive nitrogenous compounds when herbage is eaten by ruminants. Their physiological importance [9] may then be greater, in some degree, than the amounts present would suggest.

CRUDE FIBRE

The crude fibre content of herbage, a rough measure of structural constituents, is lowest during periods of rapid growth, particularly in the spring. It has been suggested [23] that depressions in the butterfat content of cows' milk following the change from stall feeding to spring grazing are due to a relative deficiency of crude fibre in a diet of young grass, but Balch and his co-workers [24] at Reading have concluded that the depression is due to poor digestion of this fraction rather than to a deficiency *per se*. Cattle are able to utilize the complex carbohydrates of crude fibre because of the microbial activity in the rumen [25]. This activity yields, amongst other products, considerable quantities of acetic acid some of which is used by the mammary gland as a source of energy and of milk fat. But the extent of crude fibre digestion depends largely on the amount and type of other carbohydrates in the ration, for these may be attacked preferentially. The starch in flaked maize, for example, provides readily available energy for the micro-organisms, and Balch obtained severe depressions in butterfat percentage when this feed was included in a ration containing 2-3 lb of crude fibre.

On the other hand, maize meal (*i.e.*, uncooked starch) gave a much smaller depression whilst crushed oats and barley had no effect at all. An additional reason for poor fibre digestion may be that in the period immediately following the change to spring grazing the microbial

population of the rumen is not adjusted to the sudden marked change in the nature and condition of its substrate. It was found with sheep [26] that there was a marked fall in the proportion of acetic acid in the rumen following a change from a hay to a pasture diet, but in the rumen of sheep maintained continuously on pasture there were no seasonal variations in the amounts or proportions of volatile fatty acids.

WATER-SOLUBLE CARBOHYDRATES

This fraction—non-structural carbohydrates of the plant—includes some sugars such as fructose, glucose and sucrose. In grass plants fructosans, which are chain-like molecules with a length equivalent to 25-30 fructose units [27], are the most abundant soluble carbohydrate. Soluble carbohydrates are included in "nitrogen-free extract" in the usual scheme of feedingstuffs analysis, but they may be determined separately and have been found to contribute as much as 30-40 per cent of the total dry matter in grass. On this score alone they are an important constituent of herbage, but possess additional interest because of the role played by carbohydrate in the utilization of protein by the ruminant [9].

Many workers have found that the soluble carbohydrate content of herbage is much lower in the autumn than in the spring, and Waite and Boyd [28] have related this difference to the physiological state of the plant. Their results suggest that grass in which the flower initials have just started to develop will usually contain more soluble carbohydrates than grass in which the growing point is vegetative. The latter condition is to be expected, in Britain generally, in tillers growing after June.

MINERALS (HYPOMAGNESAEMIA)

Trace elements will not be considered (an excellent review [20] has been published) but it is appropriate to discuss variations in the levels of some minerals in herbage in this section on spring and autumn grass, since grass tetany, which is characterized by low levels of blood Mg, occurs most frequently in these seasons and only occasionally during the summer. Whilst it is generally agreed [29 and 30] that the disease is not caused by a simple dietary deficiency of Mg, the possible long-term effects of low levels in the feed cannot be ignored. According to Blaxter [30], low levels in pasture dry matter tend to occur during periods of high rainfall and high levels during drought. Clover contains more Mg than grass. Reith [31] found a 60-100 per cent variation in the percentage of Mg in the dry matter of mixed leafy pasture during the growing season. Relatively low values occurred during April, May and early June, they gradually increased until August after which the levels were reasonably constant; Ca showed a similar pattern. These results are in agreement with those reported by Stewart and Holmes [32]. Levels of P in herbage tend to decline during the grazing season [36].

Brouwer, in the Netherlands, considers that the mineral composition of herbage is closely correlated with the incidence of tetany and that this disease occurs when the value for the algebraic sum ($K + Na - Cl - S$) m-equiv. in dry matter is high and ($Ca+Mg-P$) is low. High potassium is thought to be the prime factor (for discussion see [20] and [30]). It has been found [33] that hypomagnesaemic tetany is most prevalent when the mean environmental temperature does not exceed 14°C (57°F) and is rare at higher, i.e., summer, temperatures. This apparent effect of temperature, which has been noted by other workers [20], may be indirect and be mediated by changes in grass composition, for Dijkshoorn [34] found that K was the element most readily taken up by grass plants at temperatures below 15°C. In these conditions K levels in herbage may be high, but at higher temperatures other minerals, especially Ca, Mg and Na, are taken up in greater amounts and the proportion of K falls. Much earlier, Ferguson [35] observed that K, Na and P levels in intensively-managed pasture herbage depended to a great extent on climatic conditions, and Stewart and Holmes [32] found that K and Na levels were lowest in mid-season. Melville and Sears [36] characterized spring herbage which is often grass-dominant, as being high in protein, high in K and P and low in Ca. Although some work [37] has suggested that high ammonia levels in the rumen of grazing animals [26 and 38] interfere with the absorption of Mg from the gut, this explanation for the incidence of hypomagnesaemia has been criticized as inadequate [30] and none of the more recent, nor on re-examination the older, Dutch work has incriminated high protein pasture *per se*.

OTHER FACTORS

Following reports of breeding and other troubles amongst sheep grazing subterranean clover in Australia, and the discovery that these were due to the occurrence of oestrogens in the plant, much work has been done on the oestrogen content of British pasture herbage [39]. It has been found that spring grass has oestrogenic activity, but it should be noted that this activity is measured by its effects on the development of the mouse uterus and that there have been no unequivocal reports that it is of significance in practical animal feeding.

In British conditions the carotene content of herbage is usually fully sufficient to meet requirements, and in general there is a positive relationship to protein content [40]. In the two feeding trials referred to above [1 and 2] autumn grass had a higher carotene content than spring grass and gave higher carotene levels in blood and butterfat.

SILAGE

Differences between spring and autumn herbages may be accentuated when they were conserved as silage. The high protein content of autumn grass and the relative lack of readily fermentable soluble carbohydrate may result in considerable breakdown of protein and

the formation of large amounts of volatile bases [41]. In a comparative trial at the Rowett Institute (Dr. J. Davidson, personal communication) silage made without additives from a typical autumn grass crop containing 20 per cent crude protein was of poor quality judged both by inspection and by analysis. It was not readily eaten by stock. On the other hand, silage made in the same way from spring grass containing 13 per cent crude protein, again fairly typical material, cut from the same field in the same year, was of better quality on all counts and palatability was good. The proportion of volatile bases in the autumn silage was approximately six times that found in the spring silage; pH and butyric acid content were also high, whilst lactic acid content was low.

Summer Grass

Care should be taken not to overestimate the feeding value of summer grass. Woodman, Blunt and Stewart [42] found that there was a decline in crude protein and a rise in crude fibre in midsummer in herbage cut weekly from mixed pasture. These effects are a consequence of the slower rate of growth in this season. In the spring of 1955, I made suitable preparations for the production of high protein herbage on a field to be used in a grazing experiment. This year will be remembered for its exceptionally dry summer and the grass grew very slowly. It was, as desired, very leafy and had every appearance of quality, but analyses showed that the crude protein content never rose above 15 per cent in the dry matter.

Winter Grass, Foggage

Woodman and Oosthuizen [43] and Thomas and Boyns [44] published data on the composition and digestibility of winter grass. These suggested that, compared with grass produced during the growing season proper, its quality was rather poor. But the pastures used in these studies were of poor botanical composition, gave low yields of herbage and were not specially prepared for the production of foggage —the autumn growth of grass saved for grazing during the winter. More recent work shows [45 and 46] that high yields of foggage can be produced by suitable management. Compared with hay and silage— a fairer comparison since these are the feeds which it would replace— its nutritive value is excellent. The protein content depends on (*a*) the grass species used—it is higher in ryegrass than in cocksfoot, but for other reasons the latter species is more suitable for grazing right through the winter; (*b*) the amounts of N fertilizer applied; and (*c*) the length of the autumn rest. Foggage produced after resting pastures from September may contain 20 per cent or more of crude protein in the dry matter and need not contain less than 14–15 per cent crude protein with earlier closing. On standing through the winter the crude protein content tends to rise [46]. This is probably due to the loss, through rotting, of relatively greater amounts of dry matter than of crude

protein, since the long, older leaves of grass tillers are more affected than the younger, higher protein, leaves at their centres.

Muscular dystrophy is prevalent in the north-east of Scotland in spring amongst suckled calves turned out to grass [47]. The disease has been shown to be due to a deficiency of vitamin E (tocopherols) in the diet of their dams who are usually fed mainly on oat-straw and turnips. Since foggage might be used to replace these feeds to some extent, its tocopherol content is being determined (Corbett, unpublished). Preliminary results suggest that the amounts present are similar to those found in leafy grass during the normal grazing season [48]. Tocopherol levels do not appear to vary to any marked extent when the sward is maintained in a leafy condition, but fall to a low value as the plant matures and becomes stemmy.

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Trace Elements in Soils, Plants and Animals

J. B. E. PATTERSON

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Earlier this year the Agriculture Group of the Society of Chemical Industry arranged a symposium on this subject. It was attended by many distinguished scientists, both from home and overseas, and the papers, which are listed on pp. 106-7, combine to present an up-to-date exposition of the subject. The following does not purport to summarize the entire proceedings, but is a selection of material most likely to interest officers of the N.A.A.S.

Chelates

THE USE OF CHELATES (sometimes known as versenates or sequestrols) for controlling chlorosis in plants which has been caused by the action of heavy metals or excessive lime has developed into a routine and commercially satisfactory practice during the past five or six years. These compounds are not simple salts of metals in combination with an acid, but are organic complexes in which the metal is held firmly and is not ionized in solution.

Many trace element deficiencies in plants—such as those of manganese, magnesium, copper and zinc—can fairly easily be controlled by spraying the leaves of plants with a dilute solution of sulphates in water, or by applying these salts to the soil as solids or in solution, but salts of iron have been found to be almost useless when applied to soil, and in solution they cause scorching of leaves. "Pills" of ferrous sulphate can be sealed into holes drilled in the trunks and branches of fruit trees and will usually control chlorosis for a few years, but the process may have to be repeated every few years and branches will be weakened by too many holes being drilled in them.

It was probably a happy accident that the soils in Florida on which Stewart and Leonard first successfully treated citrus for chlorosis by as little as 10-20 g iron per tree in the iron chelate of ethylenediaminetetra-acetic acid (Fe-EDTA) had a pH of about 4.0, for this iron chelate is very much more stable under acid conditions than at pH levels of above 6. If the Florida soils had been alkaline the comparative ineffectiveness of the Fe-EDTA would have suggested that the use of chelates was uneconomic, for on alkaline soils at least ten times as much iron had to be given in this form to control chlorosis.

These unfavourable results with Fe-EDTA on alkaline soils led to a search for other similar compounds which would be more useful in correcting lime-induced chlorosis, and at present the iron chelates of HEEDDA, HEEDTA and DTPA are used fairly widely, although the results are not always consistent. The explanation is that when the iron compounds of these materials are added to calcareous clay soils two main reactions take place. In the first, the clay rapidly adsorbs some of the chelate molecules and so prevents their movement in the soil; and in the second, calcium replaces the iron and thus removes it from the reaction. Bould of Long Ashton found that he could completely control seasonal chlorosis of pears on a very calcareous soil by thoroughly watering in the comparatively small dressings of 32 g iron as Fe-EDTA and 23 g iron as Fe-DTPA, or by sub-soil injection of aqueous solutions into the rooting zone of the trees. It is therefore important that all chelates used on calcareous soils should be got down to the roots of plants as quickly as possible before they become inert.

Two iron chelates—Chel-138 and Fe-CDTA—which may be available commercially before long, have been found to be very much more stable in calcareous soils containing up to 32 per cent $CaCO_3$.

The difficulties of use on calcareous soils may be overcome if the iron chelates, especially Fe-CDTA and Fe-HEEDTA, are applied as foliar sprays at between 0.05 per cent and 0.1 per cent with a wetting agent. Both upper and lower leaf surfaces must be wetted thoroughly, especially the latter. Chlorosis of pears, plums, peaches and red currants can be controlled in this way, but several consecutive sprays may be necessary and the effect is only seasonal. All solutions must be used immediately after they have been made up because they decompose in light.

Ordinary analytical methods and radio-active isotopes show that the iron chelate molecule is taken up intact into plants, and that by the time the iron reaches the leaf and flower primordia it has become separated from the chelate complex, but how this happens is not known at present.

Factors influencing the Uptake of Trace Elements

In the study of trace element diseases in plants and in animals which obtain most of their nutrients from plants, the factors which influence

the uptake of trace elements are of interest. The chemist is often asked whether analysis of plants or soils can show if a particular deficiency may occur or if a diagnosis of a deficiency from symptoms shown by a plant or animal can be confirmed by analysis. Too often this request takes the form of a demand for "an analysis for all trace elements" without an understanding of how the figures are to be obtained or what they really mean. Long-term work at the Macaulay Institute, Aberdeen, shows that, provided the effects of drainage and soil treatment are allowed for, the most satisfactory long-term picture of trace element status of plants on any particular soil may be gained from examination of the soil.

Plant uptake cannot be related directly to the total amount of a trace element in soil, for animals may suffer from cobalt deficiency on a soil containing several parts per million total cobalt.

For some time $2\frac{1}{2}$ per cent acetic acid has been used successfully for extracting "available" trace elements from soils. Recently 0.05 molar EDTA neutralized to pH7 by ammonia has been found to be of special value for assessing the status of copper and possibly of cobalt.

In Scotland (and possibly in England also, although much less work has been done there) unusually large amounts of cobalt, nickel, vanadium and copper are extracted from poorly-drained soils by these reagents. Both acetic acid and EDTA extract similar amounts of zinc and nickel, but the latter is not such an effective agent for cobalt as the former. On the other hand, EDTA is a more powerful extractant for lead, copper, iron, chromium, molybdenum, titanium and vanadium.

Except for cobalt and nickel, the differences in soil figures are not reflected in the content of trace elements in herbage.

Good correlation has been found between copper deficiency in oats and EDTA extractable soil copper, and it is suggested that soils containing less than 1.5 p.p.m. should receive a dressing if there is any suggestion of plant or animal disorders. As a tool for diagnosis of cobalt deficiency, EDTA is probably superior to acetic acid, but this is outweighed by the fact that it extracts less cobalt than acetic acid and is a less convenient analytical reagent in subsequent operations.

The relationship of trace element deficiency diseases in animals to the levels of these elements in herbage and soils is complicated, because it involves the uptake of the element from the soil by the plant and again from the plant by the animal. Although there are areas in Great Britain where cobalt deficiency and molybdenum excess are associated with definite soil types, they are only comparatively small. However, the emphasis on increased production during the past few years has brought to the fore the importance of avoiding unthriftiness in stock where the levels of trace elements are not great enough to produce clinical symptoms but are sub-optimal.

Minerals in Herbage

Information on the mineral composition of pasture and herbage plants is being built up, especially at King's College, Durham by Brynmor Thomas, and Thompson and others. One of the main difficulties in this work is the collection of samples of herbage uncontaminated by soil. The serious effect of contamination has been shown by growing grass by soilless culture methods and adding 2, 4, 6, 8 and 10 per cent of soil of known composition to it. Only 2 per cent of added soil will increase the apparent iron and cobalt content of herbage by over 100 per cent and that of manganese by about 20 per cent, whereas the copper content is almost unchanged. It has been suggested that, as a check, the aluminium content of the herbage should be determined, and that if it is greater than 150-200 p.p.m. the sample should be rejected.

Although animals graze mixed swards, in modern leys the number of distinct species is often small, so that a knowledge of the different capacities of species for utilizing varied elements is of interest. For instance, cocksfoot tends to have a comparatively high content of manganese and copper, and red fescue of cobalt, whereas tall fescue is low in all of them. Legumes and herbs, especially plantain and chicory, are both richer sources of trace elements than grasses; the mineral content, except that of cobalt, tends to decrease as the plant matures. Moorland plants, such as heather, blackberry, molinia and nardus usually contain less iron and more manganese, copper and cobalt than do grasses.

On the Cockle Park Plots which received dressings of farmyard manure, basic slag, sulphate of ammonia and muriate of potash over a period of 50 years the effect of these dressings on trace element uptake by the herbage was only small, except that the iron and manganese contents generally followed the pH of the soil. Any marked variations in trace element composition are brought about by changes in botanical composition resulting from manurial treatments.

Often the inclusion of herbs, such as burnet, chicory, yarrow and plantain in seeds mixtures is advocated on the grounds that the mineral status of the sward is raised. In a study on three-year leys containing 0, 20, 35 and 50 per cent of these herbs the Newcastle workers found that, while there was a considerable increase in major nutrient content in the dry matter—the calcium level being raised from 0.550 per cent to 0.830 per cent—only cobalt and copper figures were significantly increased.

The second problem mentioned above of the availability to the animal of trace elements present in plants is of importance to nutrition chemists and advisers. Recently some work has been done at Newcastle with iron and with copper at the Rowett Institute by Mills. In the former, three grasses, five legumes and three herbs, all at full-leaf stage of growth have been compared with ferric chloride as a source

of iron for rats previously rendered anaemic on a diet of 35 per cent dried skimmed milk, 25 per cent dried whole milk, 30 per cent sucrose A.R. and 10 per cent vegetable fat. The criterion was the level of haemoglobin after 28 days on the supplement. Grasses proved to be the best source of iron (with timothy giving 73 per cent availability of ferric chloride) with clovers not far behind at about 50-60 per cent, while herbs were significantly less effective than grasses, plantain being the best at 55 per cent.

Copper—Functions and Interactions

By far the most work on utilization of trace elements by animals has been in trying to determine the functions of copper and its interactions with molybdenum and sulphate.

In 1945, Dick and Bull in Australia showed that if cattle and sheep received a high level of molybdenum in their food, the storage of copper in the liver was reduced and eventually fell to below the deficiency level of 15 p.p.m. in the dry matter. In Britain swayback in sheep is the most important result of copper deficiency, but there is no field or experimental evidence of a relationship between copper and molybdenum content of feedingstuffs and this particular disease. In 1953, Dick in Australia suggested that some of the differences between Britain and Australian swayback might be due to variations in the amount of inorganic sulphate in the diet and that 0.5 g per day constituted a "low normal" level. This has been followed up by Mrs. Allcroft and Miss Lewis at Weybridge who have established experimentally that increasing inorganic sulphate 3-5 times has no significant effect on liver copper levels in pregnant ewes of low or normal copper status. On the other hand, when maternal copper status is low, the foetal liver copper in lambs can be reduced by high sulphate in the diet. Kale, because of its high sulphate content or the presence of some other constituent, may also interfere with liver copper deposition.

In Australia, a copper content in pastures of above 6 p.p.m. (D.M.) is satisfactory, and in New Zealand, simple copper deficiency occurs at a pasture copper level of 3 p.p.m. Levels of less than 5 p.p.m. are rarely found in Britain, and analyses of swayback and non-swayback samples show that the copper levels are 8.4—20 p.p.m. and 6.2—35 p.p.m. respectively. Figures for molybdenum and sulphate also show that in this country there is no significant difference in swayback and non-swayback areas. This work points to some other factor besides copper, molybdenum and sulphate being important, and Mills at the Rowett Institute suggests that one or more of the following factors operates:

(1) a dietary factor or metabolic defect resulting in increased output of copper in the urine;
(2) failure to utilize copper absorbed into body tissues;
(3) failure to absorb copper from the digestive tract.

As regards (1), injection of British Anti-Lewisite, which increases urinary excretion of copper in man does not seem to have the same effect in sheep, and there is no experimental evidence to support the suggestion that molybdenum will do this in the presence of dietary sulphate.

Molybdenum and sulphate together may fulfil (2), in that they can induce a "physiological" deficiency of copper before tissue copper levels have become markedly depleted. In rats, toxic levels of zinc may impede utilization of stored liver copper, but they do not seem to influence the extent of storage. In studying the factors affecting absorption of copper from the digestive tract, Mills has found that the greater part of the copper in herbage remains insoluble after treatment with a wide range of aqueous and organic solvents and exists in organic complexes. "Bound" forms of copper have been found in the digestive tract of sheep, and even in the most acid regions no free copper ions could be detected. It therefore seems that soluble complexes of copper in foods can pass through the biological membranes and be absorbed intact. In the study of the effects of feeding diets known to cause copper deficiency disorders, it may be possible to determine whether abnormal copper metabolism in the digestive tract or failure of metabolism during or after passage of the copper through the membranes of the digestive tract are responsible.

Zinc and the Calcium-Phosphorus Ratio

Young pigs fed dry *ad lib.* on proprietary or home-mixed diets often suffer from a dermatitis known as parakeratosis. This has been found to be related to some extent to the calcium-phosphorus ratio, in that decrease in calcium or increase in phosphorus content of the diet will clear up the dermatitis, but without improving growth rate or food conversion efficiency. Bellis and Philp have investigated the observation of Tucker and Salmon in 1955 that addition of 0.02 per cent zinc carbonate would cure or prevent the trouble, and find that 100 p.p.m. of zinc added to a weaner meal containing 1.3 per cent Ca and 0.7 per cent P is satisfactory.

The following papers were presented at the symposium. They will be published in full later in the year:

Iron Chelates in Plant Nutrition. C. BOULD. Long Ashton Research Station, Bristol.

Trace Element Uptake in Relation to Soil Content. R. L. MITCHELL, J. W. S. REITH and I. M. JOHNSTON. Macaulay Institute for Soil Research, Aberdeen.

Some Nutrient Interactions affecting the Growth of Pasture Legumes in Acid Soils. E. G. HALLSWORTH, E. H. N. GREENWOOD and I. AUDEN. School of Agriculture, Sutton Bonington, Notts.

Molybdenum as an Essential Plant Nutrient for Higher Plants. E. J. HEWITT. Long Ashton Research Station, Bristol.

Role of Trace Elements in the Nitrogen Metabolism of Plants with Special Reference to Micro-organisms. D. J. D. NICHOLAS. A.R.C. Unit of Plant Nutrition, Long Ashton.

Trace-Element Contents of Herbage Plants with some Reference to their Availability to the Animal. A. THOMPSON. King's College, University of Durham.

Trace Element Uptake by Sweet Vernal in relation to Mineralogy and New Zealand Genetic Soil Types. M. FIELDES and N. WELLS. D.S.I.R., New Zealand.

Trace Elements and Crop Production in the Tropics. R. A. WEBB. A.R.C. Unit of Plant Nutrition, Long Ashton.

Dietary Factors influencing Copper Utilization by the Animals. C. F. MILLS. Rowett Research Institute.

Copper Nutrition in Ruminants. Diseases associated with Copper-Molybdenum-Sulphate Content of Feedingstuffs. RUTH ALLCROFT and GWYNETH LEWIS. Ministry of Agriculture, Fisheries and Food Veterinary Research Laboratory, Weybridge.

Factors influencing the Blood-copper Level of Sheep. HAMISH A. ROBERTSON and ARTHUR W. J. BROOME. University of Nottingham School of Agriculture.

Cobalt Deficiency in Sheep in Herefordshire. A. D. OSBORNE. University of Bristol, Veterinary Laboratory, Langford.

Incidence and Control of Cobalt Deficiency under varying Soil and Pasture Conditions in Connemara, Co. Galway. L. B. O'MOORE. Department of Agriculture Veterinary Research Laboratory, Dublin.

Effect of Zinc, Calcium and Phosphorus on the Skin and Growth of Pigs. D. B. BELLIS and J. McL. PHILP. Unilever Ltd., Sharnbrook.

Application of Chromatography to Nutritional Problems in Plants. A. H. WILLIAMS. A.R.C. Unit of Plant Nutrition, Long Ashton.

Use of Paper Chromatography in the Separation of the Valency States of the Biologically Important Metals. M. M. STEVENS. A.R.C. Unit of Plant Nutrition, Long Ashton.

The Complexing of Copper with Nutritional Components of Fruit. C. F. TIMBERLAKE. Long Ashton Research Station, Bristol.

Lucerne Breeding in England and Northern France

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LUCERNE ACREAGE in the U.K.—mostly grown in England—probably more than doubled during the War and is now over three times the 1938 figure. Few agriculturists would doubt that there is still plenty of room for further expansion.

An important factor in the post-war expansion of lucerne in England has been the high productivity of the Flamande type. The Flamande stocks and varieties, with Du Puits as the outstanding example, have given English farmers a convincing and practical demonstration of the importance of choice of variety in lucerne.

So far as suitability of varieties is concerned, Northern France and the south and east of England are rather similar. The purpose of this article is to give a brief account of work on varietal improvement of lucerne for these conditions, based on recent visits to the French national plant breeding station at Versailles and to the private station of Messrs. Tourneur Frères at Coulommiers and also on the writer's own work with lucerne at Cambridge. Lucerne breeding is of course in progress at Aberystwyth, but is regarded as lying outside the scope of this article.

Adaptation and Utilization

Any plant breeder must try to produce varieties adapted to conditions in the area which he serves, and suitable for the purposes the cultivator has in mind. Lucerne breeders usually give primary importance to the duration and severity of the winter when considering adaptation. For areas with a continental type of winter (long and severe) varieties are needed with a long period of dormancy. A typical example is the variety Grimm, which like all late varieties shows a strong influence of the wild lucerne *Medicago falcata* (late start of growth, slow recovery after cutting, pronounced rosette stage in autumn and winter, much yellow pigmentation in the flowers, relatively fine stems and small leaflets). At the other extreme are areas in which growth continues, often with irrigation, all the year round. Here non-hardy varieties are grown, like African and Hairy Peruvian in California. Under English and French conditions such varieties suffer severe winter killing, while Grimm and similar varieties, though very persistent, fail to reach the highest levels of productivity because they cannot make full use of the growing season. The Flamande varieties represent a suitable

compromise, being fully winter-hardy in England and France and yet making an early start in the spring and recovering quickly after a cut.

Most farmers growing lucerne probably want maximum productivity and are aiming at three and possibly four cuts in the season; they would not require extreme persistency, as the crop is probably part of a more or less well defined rotation. Here again, the Flamande types show to advantage and their main defect—coarseness when allowed to stand to flowering—is relatively unimportant. Other farmers might attach more importance to quality of hay and to persistency and might be prepared to sacrifice some productivity; if so, there is room for a variety with rather more influence of *M. falcata* than the Flamande varieties show.

The origin of Flamande lucerne is not known, but French breeders surmise that its good adaptation to local conditions is due to natural selection, occurring when farmers in Flanders continued saving their own seed for generation after generation. Once the value of the general type was recognized, French breeders did a considerable amount of selection within it and several named varieties and stocks were marketed, lead by the now famous Du Puits.

Methods of Breeding

The four features of lucerne which decisively influence the methods available to breeders are that it is (*a*) a herbage crop, (*b*) perennial, (*c*) cross-fertilized (though not completely self-sterile) and (*d*) auto-tetraploid. The last feature will not be considered further in this article, beyond noting that it raises some intriguing problems when genetical aspects of lucerne improvement are considered.

Of the features (*b*) and (*c*) it may be said that they are common to many herbage crops and that they introduce characteristic difficulties and possibilities. Obviously breeding is slower in perennials than in annuals, but there is the advantage that parents can be kept alive for long periods and can be multiplied vegetatively. Cross-fertilized crops show great variability even within local populations or varieties and thus seem to offer great scope for selection, but if inbreeding is used to reduce variability within families, it inevitably leads to loss of vigour; attention has therefore to be focused on the performance of inbreds in crosses. A difficulty attending breeding work on all herbage crops is that for some purposes the breeder must space out his individual plants, and it is hard to relate performance under these conditions to performance in close drills or broadcast stands.

THE POLYCROSS METHOD

A method which has been used by many lucerne breeders, and which is still in use in both England and France, is the polycross method. Its main use is for selection within an existing population.

Briefly the steps involved are:

1. Selection of a number of potential parents for progeny testing.
2. Propagation of these by cuttings to form clones.
3. Planting the clones in replications in a polycross nursery, so arranged as to allow each clone to be pollinated by all the others.
4. Bulking seed from each clone separately.
5. Carrying out a yield trial of these polycross progenies, and finally
6. Making an isolation plot of the parental clones which have given the best progenies.

The seed from this forms the foundation of a new strain for variety tests. This method is certainly very logical, and has the advantage that the main judgment is based on a yield trial which can be carried out under conditions approximating to farm practice. Its disadvantages are that it is very slow (the steps described may take 15 or 16 years, though short cuts are frequently made) and that it restricts the number of parents which can be tested. There can be little doubt that it is a good method of maintaining a desirable population, but it remains to be proved by direct experience that it is capable of giving useful improvement.

At Coulommiers a new variety has been produced by this method, with a slight variation in that the polycross nursery was planted with open-pollinated progenies instead of clones. The variety is of the same general type as Du Puits (which was bred by Tourneur Frères) but is a little later in flowering and growth, somewhat leafier and with a higher protein percentage, the breeders having in mind suitability for artificial drying. Selection has been practised throughout for a uniform reddish-purple flower colour and the variety has been named Cardinal.

Incidentally, the aim of incorporating a distinctive feature as an inherent trade-mark of a new variety is occupying lucerne breeders at both Coulommiers and Versailles, where work is proceeding on seedlings having two unifoliate leaves instead of the usual one. This preoccupation with easy recognition of varieties may be fostered by the French system of registering varieties, but easy identification has obvious advantages for any certification scheme and should help to give farmers confidence in the varietal authenticity of the seed they purchase.

Inbreeding

At all the three stations mentioned, work on inbreeding lucerne is in progress. In France it seems to be mainly used to fix desired characteristics, and after a moderate amount of selfing, lines are crossed by hand, or are pooled in small groups in isolation to test their performance in crosses. Presumably the ultimate aim would be to use the inbred lines as the basis of a strain. The advantages of this are that one has a firmer control over variability and that there is less risk of

losing good parents by virus infection (though this does not seem to be a serious risk in lucerne breeding). The aim of putting lucerne breeding on the same footing as hybrid maize is not considered practicable at either Versailles or Coulommiers. At Cambridge, the theoretical advantages of the hybrid maize system are considered great enough to warrant a serious study of its application to lucerne, in spite of the genetical and technical difficulties involved.

All the work so far described is concerned mainly with making use of the existing variability in populations of cultivated lucerne by more or less refined methods of selection. At Cambridge work is also in progress on the use of wild forms of lucerne, in breeding a variety suitable for less intensive utilization, less coarse and somewhat more persistent than Flamande, but not so far behind it in yield as the available varieties of this type. Experience so far suggests that this aim is not unattainable, but the degree of success achieved so far will not be known until the results are obtained from a trial sown this year. No work of this kind was seen at Versailles or Coulommiers, though at both stations attention is being paid to reducing the coarseness of the Flamande type.

Prospects for the Future

Among the material which is nearing the stage of commercial production at these three stations it is reasonable to expect some useful, but not, perhaps, spectacular improvements. What then of the more distant future? Are there prospects of more striking advances in lucerne varieties? Here of course one can only speculate.

In the first place existing methods may be applied to new problems. In both France and England, Verticillium Wilt and stem eelworm are beginning to give trouble. Stem eelworm of lucerne, at least in England, seems to be mainly introduced with the seed and should be controllable by seed disinfection. If this fails, the experience of lucerne breeders in both North and South America shows that resistant varieties can be produced. At present no source of resistance to Verticillium Wilt has been found, but then it took the U.S. lucerne breeders some time to find resistance to bacterial wilt. New problems may also arise in connection with the use of irrigation, which is much in the news at present; the most economic use of water will presumably require varieties which are even quicker in recovery after cutting. Work on these and other problems requires a constant searching through the forms of lucerne cultivated or growing wild in different parts of the world; for example, resistance to bacterial wilt was ultimately found in lucerne from Turkestan.

Because of the enormous range of variability already existing in lucerne, breeders have tended to neglect artificial methods of extending the range, such as higher degrees of polyploidy or induced mutations.

By colchicine treatment, hexaploid lucerne has been produced at Coulommiers. It gives an appreciably higher forage yield than Du Puits but has the usual disadvantage of artificial polyploids—its seed yield is too low. Selection for higher seed fertility is producing an improvement and may ultimately make hexaploid lucerne a commercial proposition. The possibilities of induced mutation will be considered in a future article.

Bacteriological Samples in Milk Production Advisory Work

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Advisory officers of the Ministry of Agriculture, Fisheries and Food, when investigating problems of hygienic milk production, frequently find it necessary to take samples for bacteriological examination, and much attention has been given during the last ten years to methods of sampling, testing techniques and the interpretation of results. This article reviews the procedure now used in England and Wales and refers to methods employed in other countries.

Procedure in the United Kingdom

IN ENGLAND AND WALES, farm milk undergoes unofficial tests for keeping quality at the receiving dairy; designated (T.T.) supplies are also subjected to a statutory methylene blue test under which the reduction time must not be less than 4½ hours in summer and 5½ hours in winter. When advising farmers on hygienic methods of milk production, advisory officers first carry out a thorough visual inspection of equipment and methods. As sources of contamination are not always easy to detect however, it is necessary in obscure cases for samples to be taken and sent to the local advisory laboratory for examination. So that the bacteriologist can deal with the samples to the best advantage, the advisory officer also submits a report giving details of the problem and the farm conditions.

At one time advice was based largely on the results of milk samples, but since many of the problems encountered are associated with faulty cleansing of equipment, advisory officers now make extensive use of rinse or swab techniques for assessing the bacteriological condition of equipment. A standard procedure for taking advisory milk samples, rinses and swabs, and a uniform testing technique have recently been recommended by the N.A.A.S. and are in general use throughout England and Wales [1 and 2].

MILK SAMPLES

These may be taken from the bulk milk as a check on the bacteriological quality of the finished product; alternatively they may be taken in series at different stages of production i.e., from the udder of one or more cows, and from the pail, cooler and can, to trace the point at which contamination is taking place. Bacteriological examination is normally carried out after storage of the samples at atmospheric temperature until 10-18 hours after production, and consists of a colony count on Yeastrel milk agar at 30°C, a coli-aerogenes organisms test at 30°C, together with a test for keeping quality at 22°C if desired. The methylene blue and resazurin tests have been found of limited value in advisory work, and are only applied in particular cases. When the evidence suggests that cleansing of equipment has been faulty over a period, a laboratory pasteurization test for the enumeration of thermoduric bacteria can give useful information [3]. Tests for abnormal secretion, by the Breed smear, Whiteside test, or microscopic examination of centrifuged deposit are carried out when necessary, and, if a taint or other abnormality is suspected, the milk is subjected to special tests appropriate to the problem.

RINSES AND SWABS

It is important to employ a standard technique when rinsing or swabbing, as it has been shown that the proportion of the total organisms removed from an equipment surface by these methods is subject to much variation. Hoy & Rowlands [4] using a technique whereby 500 ml sterile rinse was passed through the teat-cup cluster five times, found that this treatment removed just over 60 per cent of the organisms from two relatively clean clusters, and the proportion removed from two heavily contaminated clusters was 53 per cent and 35 per cent. Claydon [5] in the United States found that a rinsing treatment which introduced a flexing action with suction, similar to machine milking, would remove more organisms from rubber teat-cup liners than rinsing and shaking. Other workers have suggested that rinsing is more efficient if carried out with a solution warmed to blood heat [6] and that skim-milk is a better rinsing medium than an aqueous solution [6 and 7]. For general advisory purposes, however, a simple rinsing technique using a cold aqueous solution appears to give sufficiently reliable results, provided it is carried out in a standard manner.

Standard techniques for rinsing milk cans and bottles and a swab method for the examination of milk plant surfaces, devised under the war-time National Milk Testing and Advisory Scheme [8 to 10] have been extensively used for advisory work in creameries. Under the N.A.A.S. sampling procedure these techniques have been suitably modified and adapted for testing the various types of farm dairy equipment. A 500 ml quantity of sterile ¼ strength Ringer's solution is

used for rinsing items such as the teat-cup cluster, pail, receiver and cooler, or a greater quantity for large equipment, such as a combine milking plant. The equipment is agitated where practicable during rinsing and the operation is normally repeated once with the same solution, allowing a short interval for the first rinsing to wet and loosen the bacteria on the equipment surface. A swab method is also prescribed, but its use is only recommended for equipment which cannot be rinsed [1]. It is essential that samples reach the laboratory for examination within a few hours of sampling as it has been shown that prolonged storage may significantly affect the results [11]. The rinse or swab solution is examined by the colony count test on Yeastrel milk agar at 30°C, tests for milk souring organisms, coli-aerogenes organisms or thermoduric bacteria being carried out when necessary.

INTERPRETATION OF RESULTS

Results of advisory samples need careful interpretation. Since the test results are subject to the variable influences of prevailing atmospheric temperatures, conditions of sampling, age and type of sample etc. no hard and fast standards can be applied. To ensure a measure of uniformity, however, certain broad guide standards are borne in mind by the bacteriologist, who then makes due allowance for variable factors which may have affected particular samples. It is helpful if the results are placed in the following three categories:

- Those which are thoroughly satisfactory, implying that no improvement is desired;
- Those which are poor and indicate an immediate need for remedial action; and
- Those which are of intermediate quality suggesting that further improvement is desirable if a good bacteriological standard is to be maintained consistently.

Under normal atmospheric conditions in England and Wales, milk that is produced with good methods from healthy cows and efficiently cooled usually gives a colony count at 30°C below 20,000/ml, and contains only minimal numbers of coli-aerogenes organisms when tested at 10-18 hours old. A colony count above 100,000/ml and coli-aerogenes organisms in 0.01 ml normally indicates faulty production methods.

In the interpretation of rinse and swab results it is necessary to make allowance for the area of equipment examined. For example, the internal surface of a teat-cup cluster seldom exceeds 1 sq. ft while that of a medium-sized cooler may be as much as 9 sq. ft, and it is reasonable to allow for this factor in assessing the results. Rinses and swabs of equipment which has been effectively cleansed and sterilized will normally show a colony count below 5,000-10,000/sq. ft of surface tested, whereas a colony count exceeding 50,000/sq. ft indicates unsatisfactory cleansing.

CONTROLLED GRAZING FOR FATTENING CATTLE AND SHEEP

(See pp. 129-35)

CONTROLLED GRAZING WITH BEEF CATTLE AT LONGBANK

The stock are clearing up the end of the last strip. The remainder of the field, part of which is seen in the foreground, has been saved for hay.

STRIP GRAZING OF BEEF CATTLE AT CRASTER SOUTH FARM

Commenced in 1952, this was the first observation study in the county.

PLATE I

CONTROLLED GRAZING FOR FATTENING CATTLE AND SHEEP

(See pp. 129-35)

PADDOCK GRAZING OF SHEEP AT FLOTTERTON

Some of the ewes have gone through the creep with the lambs one difficulty of this system after clipping time.

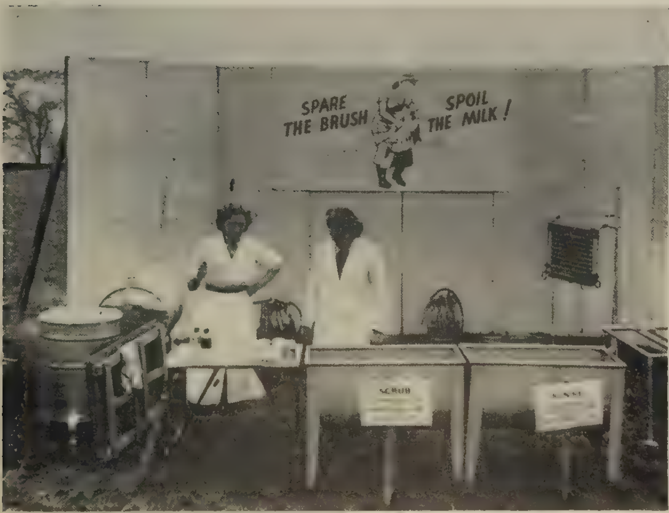
PADDOCK GRAZING OF SHEEP AT HETTON STEADS

A 30-acre field has been split into three paddocks and is being grazed with 140 Half-Bred ewes with Cross Suffolk twin lambs.

PLATE II

SOME EXPERIENCES WITH MOBILE DISPLAYS

(See pp. 136-8)



The Dairying Display.

Milk Equipment Cleaning.

PLATE III

SOME EXPERIENCES WITH MOBILE DISPLAYS

(See pp. 136-8)

Pig Weighing.

Concrete Mixing and Laying.

PLATE IV

In the examination of advisory samples and the interpretation of results the aim is to give the producer reliable information on the efficiency of his milk production methods so that faults may be remedied and sound advice given where improvement is required. A more detailed discussion of the examination of advisory samples in England and Wales has been given by Bird, Egdell and Thomas [12].

SCOTLAND AND NORTHERN IRELAND

Clean milk advisory work in Scotland is carried out partly by inspectors under the Local Authorities and partly by advisers attached to the three Scottish Agricultural Colleges, who investigate the more difficult problems. The colony count and coli-aerogenes organisms tests at 37°C have been retained as the official control tests for designated raw milk supplies, and Smillie [13] has reported that the elimination of coli-aerogenes organisms is the most frequent problem requiring investigation. Rinses, swabs and serial milk samples are used in advisory work for tracing sources of contamination and the methods of sampling and testing are similar in most respects to those employed in England and Wales. In Northern Ireland T.T. milk is required to comply with a colony count standard of 50,000/ml at 37°C with coli-aerogenes organisms absent from 0.01 ml. Advisory officers rely for the most part upon verbal advice to milk producers, followed by examination of advisory milk samples. When rinses are taken, the N.A.A.S. sampling procedure is followed [14].

Methods used in other Countries

It is not easy to gain a complete picture of methods used in milk production advisory work in other countries since little has been published on the subject. Several papers have recently appeared describing routine control testing of milk supplies in various countries and a feature which stands out is the extent to which quality payment schemes are used to encourage clean milk production. Differential payment for milk based partly or wholly on results of the methylene blue test is in operation in a number of countries including Norway, Sweden, Denmark, Finland, Switzerland [15], part of Holland [16], and also New Zealand [17]. A temperature compensated methylene blue test is used for this purpose in Holland [16].

Standard techniques for "sanitation tests" of containers and equipment by rinsing or swabbing have been published in the United States. The standards recommended are comparatively high—namely that there should not be more than 1 organism per ml capacity of the container rinsed and that a swabbed surface should give a colony count in the swab solution below 500 per 40 sq. in. There is no specific mention of milking machines in the techniques and it is uncertain how far these methods are employed in farm advisory work. For the grading of raw milk it is officially recommended that supplies are

judged on the average result of four successive samples, and that the average colony count at 32°C should not exceed 200,000/ml for milk to be pasteurized and 50,000/ml for milk to be consumed raw [18].

Rinses and swabs are not employed in advisory work in New Zealand. Riddet [17] reports that advisers make a close inspection of the farmers' milking plant and equipment and where necessary give advice on cleansing. The purity of the milk is safeguarded by testing the milk and cream as received at the depots, and varying the price according to the result. In Canada also, milk inspectors or field-men rely mainly on visual inspection and only use rinses and swabs to a limited extent [19].

If farmers in Holland frequently deliver milk of unsatisfactory quality, their farm equipment may be examined by a rinse test but no general standards are in force [16]. A rinse test is sometimes used in Belgium if a producer of designated milk has difficulty in maintaining the required methylene blue test standard of 5½ hours for "Mark A" milk and 8 hours for "Mark AA" milk. The quantity of rinse used is proportional to the size of the utensil, and the result is considered satisfactory if coli-aerogenes organisms are not found in 1 ml of rinse water [20].

SCANDINAVIAN TECHNIQUES

Great interest is shown in rinsing and swabbing techniques in Scandinavian countries, particularly for assessing the cleanliness of milking machines. An unusual development in rinsing technique is reported by Leesment [21] in Sweden. A special device is used to "milk" 2,000 ml of sterile water by vacuum from a 5-gal can through the teat-cups and long milk-tube into a sterile jar placed in the milking machine pail. This device is being used experimentally in a wide-scale investigation of the problems of cleansing and disinfecting milking machine clusters on farms. Results are provisionally being placed in five categories—"Very good (Colony count 0-50/ml); Good (50-500/ml); Satisfactory (500-5,000/ml); Not good (5,000-50,000/ml); and Unsatisfactory (over 50,000/ml)". Since a colony count of 5,000 ml is equivalent to 10,000,000 per cluster, it appears likely that the Swedish workers will eventually be able to raise these standards considerably.

Norwegian workers have recently been discussing advisory bacteriological standards for milking machine clusters. Tjotta and Solberg [22] suggest that a colony count of 50,000 per cluster is the maximum which should be tolerated when a cluster is rinsed immediately before milking with sterile skim-milk at a temperature of 37°C. In their opinion the colony count of a cluster rinsed with a cold aqueous solution should be considerably below that figure. They describe a trial of an automatic plant for flushing milking machine units and sterilizing with boiling water on a farm, where the results were well within this standard over a period of three months.

FREQUENT TESTS IN DENMARK

Tests are frequently made of the cleanliness of milking machines in Denmark where swabs are now more popular than rinses—but no standards have been adopted because of the difficulty of defining the area swabbed [23]. Concerning advisory plate count standards for farm milk, Overby states that for raw milk delivered to Copenhagen fluid market: "Up to 50,000 c.c. is considered excellent, 50-100,000 c.c. fairly good, and milk with a count above 200,000 c.c. unsatisfactory" [23]. The keen interest shown by the Danes in the bacteriological quality of raw milk is illustrated in the number and frequency of official control tests applied to farm milk supplies. Milk which is to be pasteurized is examined every month by the methylene blue test, filtration test for dirt and microscopic examination for abnormal secretion, and every three months for coli-aerogenes organisms and *Brucella abortus*. Milk to be consumed raw is examined every 1-2 weeks, by all the above tests together with a plate count and a test for haemolytic streptococci [18]. An indication of the standard attained by Danish producers is given in figures quoted by Koch [24] for milk entering the town of Aarhus. He reports that of 19,435 samples of mixed a.m. and p.m. milk tested in 1956, 83.5 per cent had a methylene blue reduction time of 4½ hours or over.

SWISS METHODS

Although bacteriological methods are not used for testing farmers milking equipment in Switzerland, the milk cans delivered to the farm by dairies are frequently examined by rinsing or swabbing. The bacterial count for the whole surface of a 40-litre can must not exceed 40,000,000, which is considered the most stringent standard that can reasonably be applied in view of the delays which may occur between the cleansing of the can at the dairy and delivery at the farm, and the limited facilities for treating cans at the smaller dairies [25]. Owing to the same difficulties, rinses of milk cans are seldom taken on the farm in Britain, where producers are invariably advised to give the cans further treatment on the farm before use if there is any doubt as to their bacteriological condition.

Summary

Considerable attention has been paid in Britain to the development of techniques for taking and testing advisory milk samples, rinses and swabs. It has been found that as a supplement to visual inspection the discriminate use of advisory samples is of great assistance to the advisory officer in pin-pointing sources of contamination and providing sound advice to milk producers. It seems that this country has probably made a greater advance than any other in the use of advisory samples for the speedy solution of bacteriological problems in milk production.

Though rinses and swabs are the recognized methods of checking the sterility of milking equipment in various other countries, sampling techniques and interpretation of results differ widely, and it is difficult to judge how far these methods are used in day-to-day farm advisory work.

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Reviews and Abstracts

Animal Breeding

Genetic studies and progeny testing based on results of pig fattening tests (translated title). D. Osterhoff. *Z. Tierz. Zücht Biol.*, 1956, **68**, 199-240.

This study of progeny testing schemes for pigs in Sweden, Denmark, and Germany is very relevant to the similar scheme which is being started in Great Britain on a national scale.

In the Swedish scheme an analysis was made of the litter records of pigs intended for testing, and it was found that the pigs chosen were not representative of the litter as a whole, but heavier on the average, especially in large litters. This bias made the analysis of growth rates somewhat dubious as the heavier pigs at weaning subsequently grew faster. As a practical procedure it is recommended that all pigs within 9 lb on either side of the average weight for the litter at 7 weeks of age are considered and chosen at random within these limits.

Material from all three countries was used to calculate heritabilities (i.e., the proportion of the observed variation which is genetic in origin). Generally results from different countries agreed. The average heritabilities for the most important characters were:

Length of carcass . . .	0.66
Thickness of backfat . . .	0.48
Thickness of belly . . .	0.67
Daily gain in weight . . .	0.21
Food conversion . . .	0.26
Predisposition to lung infections .	0.07

Results obtained for carcass measurements, growth rate, and food conversion agreed well with previous results. The low value of 0.07 for predisposition to lung infections makes the prospect of breeding resistant pigs remote.

The accuracy of the progeny test was checked against varying numbers of pigs in each test group and varying numbers of groups from each boar. While a test based on four or five groups of four animals each was found to be dependable, better use could have been made of the pen space by testing groups of only two animals from more litters.

In using progeny testing results to choose boars, it was shown that the full brother of a successfully tested group would be preferable to the son of a progeny tested boar.

J.W.B.K.

A Genetic Study in Steer Progeny Groups during successive Growth Periods. J. URICK, A. E. FLOWER, F. S. WILLSON and C. E. SHELBY. *J. Anim. Sci.*, 1957, **16**, 217-23.

How would the offspring of animals selected under indoor winter feeding conditions perform on the range where a large proportion of American beef animals are produced? To answer this question, two hundred and five spring-born Hereford steer calves from 23 sire groups were examined for rate of gain during three successive post-weaning growth periods. Results were as follows:

Period	Feeding level	Daily gain
		lb
First Winter	Moderate fattening ration	1.88
Second Summer	Grazing on mountain range	1.82
Second Winter	Fattening ration	1.93

Gains during the two winter periods showed a very close genetic relationship; this suggests that selection for rate of gain in one winter period would efficiently improve the same trait in the other. The genetic relationship between gain on summer range and on winter fattening rations was somewhat lower, though still high. Heritability of rate of gain was about 40 per cent, except during the final fattening period, when it fell to 9 per cent.

The authors conclude that selection in one environment should result in an appreciable genetic gain in the other, but that for maximum production, the selection should be done in the period, and under the nutritional conditions for which the commercial stock is intended.

R.C.R.

A Genetic Study of Weight at Five Ages in Hampshire Swine. J. V. CRAIG, H. W. NORTON and S. W. TERRILL. *J. Anim. Sci.*, 1956, **15**, 242-56.

Rapid growth in pigs is of great importance to the commercial producer and this paper deals with selection for this character in Hampshire swine. The age of selection varied during the course of the experiment from 150-180 days and weight at the particular age was the criterion used. Ten generations of selection to increase growth rate and, concurrently, eight generations to decrease it, are described. There was relatively little inbreeding—on average 5 per cent with a maximum of 13 per cent and, since the response throughout was proportional to the selective pressure applied, complications due to epistatic effect were unlikely. The difference between selection lines compared with the selective effort afforded estimates of heritability (0.17 at 154 days, 0.16 at 180 days). These were in close agreement with estimates from offspring-parent regression methods but not with those from the less accurate variance component

technique. From the information on heritability and on genetic correlation between weights at different ages, the authors conclude that if indirect selection for final weight were practised at an earlier age, it would be without effect if birth weight were the criterion; at 21 days it would be 20 per cent as efficient as direct selection and at 56 days its efficiency would be 50 per cent.

It would be misleading to quote the mean 180-day weights in the "fast" and "slow" lines at the end of selection because there were very large fluctuations in mean level during the experiment, but the "fast" line was always larger at 180 days than the "slow" one.

A.G.D.

The Progeny Assessment of Dairy Sires for Milk: the use of Contemporary Comparisons. ALAN ROBERTSON, A. STEWART and E. D. ASHTON. *Proc. B.S.A.P.*, 1956, 43-50.

The method now established as a routine calculation in the Bureau of Records of the Milk Marketing Board for assessing the merit of a dairy sire is that of comparison of the daughters of the bull with other heifers appearing in the same herd in the same year—the method of contemporary comparison. A bull will usually have daughters in several different herds, and the simple yet statistically best method of arriving at the overall contemporary comparison is explained. The method is applicable to both A.I. bulls and bulls used in natural service. Fifteen hundred bulls have now been assessed by contemporary comparisons, and its superiority over using simple daughter averages is now obvious. Although most of the bulls with high daughter averages were also fairly highly assessed on contemporary comparisons, there were many bulls having a high contemporary comparison but not a high average daughter yield. To use the actual average is not only inaccurate but restrictive in that many good bulls would not be considered at all. An interesting though surprising result from contemporary comparisons is that there are very few bulls capable of raising or depressing yields by more than 100 gal. While maintaining that the contemporary comparison is the best simple method of picking out the best bulls for milk yield from a breed, the authors emphasize that milk yield is only one of the desirable characteristics of a dairy cow, though perhaps the most important.

ST.C.S.T.

Farm Management

Changes in Farm Profits

It is instructive to examine profit trends on individual farms over a number of years, and to discover the factors responsible for the varying success of different farmers. The changes taking place in a group of 20 East Anglian farms from 1935 to 1955 are surveyed in a recent report

from Cambridge [1]. The average trading accounts for 1935 showed a farm income of £363. If these farmers in 1935 had been receiving the same prices for their produce as in 1955, this farm income would have been £894. In fact, the farm income in 1955 was £1,610.

The reasons for this increase in income were apparent in the trading accounts when the 1935 figures were re-valued at 1955 prices. Among the costs, it was found that rather less labour was used in 1955, but machinery costs increased nearly two-and-a-half times. Feedingstuffs purchases were almost unaltered, but seeds increased by nearly 50 per cent, and the use of fertilizers was more than quadrupled. On the receipts side, cattle and poultry sales increased a little, but sales of sheep and pigs declined. There was, however, a substantial increase in cash crops for sale—particularly barley, sugar beet and potatoes. And on balance, net output increased from £4,271 to £6,125—by 43 per cent. This more than sufficed to meet the additional costs incurred in using more fertilizers, machinery and so on.

There was, moreover, evidence of increased efficiency in the use of resources. Net output per £100 of labour (including manual work carried out by the farmer) increased by 62 per cent. Although more machinery was used, net output per £100 labour and machinery rose by 20 per cent. Overall, net output per £100 net inputs (including the occupier's labour and interest on capital) increased from £108 to £122. To sum up, farm income per farm increased from £363 to £1,610. Of this, £531 (from £363 to £894) was due to changes in the general level of prices. The remainder (£716) was due to better farming.

Blagburn [2], in a similar study, showed how this "better farming" took place. He analysed the changes in the economy of 51 farms—mainly in Buckinghamshire and Oxfordshire—from 1943 to 1953. The farms studied remained approximately the same size during the period, and the occupiers were unchanged. But some of the farmers succeeded in greatly improving their incomes over the years whilst the financial position of other farmers declined. For the sample as a whole, there was an increase in economic efficiency of about 8 per cent—total expenditure per £100 of gross output was £90 at the end of the period compared with £98 at the beginning of the period.

However, almost half the farms under review showed substantial profit variations during the ten years—11 farms showed a decline in profits of more than £3 per acre, but 13 farms managed to improve their profits by more than £3 per acre. The main factor responsible for increased profits was a substantial expansion in output with little change in the rate of expenditure. Those farmers achieving the greatest profit increases did so by improving techniques to obtain higher yields and at the same time adopting more intensive systems of farming—mainly by an increase in livestock production. More feedingstuffs had to be purchased for the extra livestock kept, but the higher output was secured

without using more labour and with little or no increase in machinery costs. In other words, those farmers who improved their financial position did so by increasing the size of their farm businesses and thereby spreading the overhead expenses over a greater output.

Most of the 11 farms with reduced profits showed a substantial decline in output—ranging from about £1 to as much as £10 per acre—the main reductions being in sales of milk and crops. Reduced income from crop sales was the result of a general tendency to replace tillage with grass. It was not accompanied, however, by any marked increase in livestock or by a reduction in food purchases as might have been expected. Neither were the other farm expenses reduced sufficiently to compensate for the reduced production from the farms.

It was significant that on two farms with reduced profits, attempts made to intensify the farming system resulted in lower yields and greatly increased overhead charges. Thus, whilst intensification of the farming system is a potential method of obtaining a substantial increase in profits, it may have the opposite effect if the level of yields is not maintained, or if the effect on overhead charges is not closely watched.

The lesson to be learned from these studies is that, in general, higher profits are most readily obtained by increasing the output of farms. On cash crop farms, this may be achieved by increasing the yields and acreages of sale crops. On mixed and livestock farms, greater numbers of the more productive livestock, with, if possible, concurrent increases in yields, may achieve a similar result. But disappointment will result if greater output is only achieved at the expense of lower yields and greatly increased overheads, or if attempts are made to reduce output without substantial reductions in the general expenses of farming.

Incentive Schemes in Agriculture

Labour incentive schemes are widely used in industry and have proved highly successful but, with the exception of piecework payments for root crops, incentive payments have not been extensively adopted in agriculture. More farmers are however becoming interested in such schemes. Strong [3] has reported on several types of incentive schemes whereby wage payments are directly related to the results achieved. Most of the schemes discussed relate to milk and pig production, although incentive schemes for crop production are briefly mentioned. The author concludes that target-setting schemes are to be preferred to straight payments where possible, although "circumstances alter cases" and straight payments have advantages which make them worth while under certain conditions. This report is not intended to be a comprehensive work on the subject. It is as described by its title, "A Farmer's Guide to Incentive Schemes", discussing the advantages of the various methods and pointing out a number of pitfalls awaiting the unwary. As such, it can be confidently recommended to farmers and advisers when incentive schemes are under consideration.

Farm Management Accounting

In recent years, new ways of analysing farm accounts and records have been developed in order to spotlight weaknesses in farm organization and operation. This approach to farm management problems has highlighted the fact that many farmers still keep inadequate financial records and are unaware of the benefits they can derive from relatively simple management accounts. Any farmer who employs the services of a professional accountant and is at all management conscious should seek more than a formal statement of profit or loss designed to satisfy the tax inspector. The recent book by Cornwell [4] —himself a practising accountant—is a timely reminder to the agricultural accountants that there is a pressing need to provide a service to farmers as the managers of businesses. At the moment farmers look to farm management specialists in the National Agricultural Advisory Service and at the Universities to provide that service. Cornwell urges that there should be closer co-operation between the farmer, the accountant and the management adviser to ensure that the farmer derives in full the benefits that can flow from such a partnership. "Farm accounts" he says "*should* be designed primarily to serve as a tool of management, that is, upon the basis developed by the whole-time specialist in farm management advisory work". The reader of this book—whether he be farmer, accountant or adviser—will find much in it of interest about the principles of management accounting and their application to agriculture.

The new edition of "The Farm as a Business" [5] also emphasizes the importance of farm accounts and records in successful farm management. It not only shows how to array the facts, but also how to interpret them and how to draw up better plans for the future. This handbook has in fact been extensively re-written in the light of experience gained in the handling of new techniques and it incorporates the lessons learned from practical experience in a very large number of cases where farm management advice has been sought and given. It includes a new section on capital budgeting and has an impressive collection of facts and figures on a wide variety of farming enterprises.

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A.J.
L.N.

Poultry Husbandry

Fat in Poultry Feeding

Fat in poultry rations continues to be a matter of great interest to chicken rearers, particularly where the birds are intended for slaughter as young table chicken. The widespread use of fat in broiler rations in the U.S.A. arose from the need to find an outlet for animal fat previously used in soap which is being increasingly replaced by synthetic detergents. As a source of energy, fats have distinct advantages over the customary main forms of energy available to the poultry keeper—cereal grains - because their energy levels are substantially higher than cereal carbohydrate foods. Superficially, therefore, it could be concluded that replacement of the cereal part of the bird's diet by fat to the limit palatable by the bird is indicated. But a straight replacement of grain by fat has often led to no improvement in growth and food conversion or even depression, while if the supplementation has been successful the venture has been economically unsound. The first aspect has been the subject of numerous research papers published recently; the second has recently been reviewed by Allcroft.

In an account of "Fat Studies in Poultry" by J. BIELY and B. MARCH (*Poultry Sci.*, 1954, **33**, 1220-7), the relationship between optimum protein and fat levels is discussed. With young chicks it was found that fat added to a 19 per cent protein diet resulted in depressed growth and feed efficiency, but with higher levels of protein (24 and 28 per cent), growth was either unaffected or stimulated and food conversion improved. Broadly the same results were experienced with turkey poults.

The relationship between protein levels, other nutrients and fat is discussed by Biely and his co-workers in other recently published papers, viz., "Fat Studies in Poultry, 5", B. MARCH and J. BIELY (*Poultry Sci.*, 1956, **35**, 545-9); "Folic Acid Supplementation of High Protein-High Fat Diets" (*ibid*, 1956, **35**, 550-1); "Fat Studies in Poultry, 3" (*ibid*, 1955, **34**, 39-44). The general thesis of these papers is that the higher energy level due to the inclusion of fat can only be efficiently utilized if protein and other nutrients needed for growth are also increased. The bird can then make use of the higher quality energy food provided and the nutrients are available to support the increased growth rate. A consequence is, of course, an improved food conversion rate. Alternatively, if no increase in the protein levels and those of certain other nutrients, e.g., choline, methionine, etc., is associated with the addition of fat, the bird may not be able to supply the body building foodstuffs required by a stimulated growth rate, or it may be able to do so wholly or partially by an increased rate of food consumption. In this event the growth rate may not be improved, or if it is, the food conversion rate becomes less favourable. It would seem that it is the failure to make the necessary adjustments in the make-up of the diet on the addition of

fat which has been responsible for the reported inability in some quarters to demonstrate improved growth and food conversion.

The economics of using fat in broiler rations needs careful consideration, similarly, price differentials between fat and other energy foods in this country as opposed to the U.S.A. In "The Use of Fats and Oils in Poultry Feeding", W. M. ALLCROFT (*Agric. Rev.*, 1957, **2**, No. 10, 21-4), points out that if a normal broiler ration with 22 per cent protein costs £40 per ton, one supplemented by and balanced for 5 per cent fat would cost about £46 per ton. The former diet might give a food conversion rate of 3.5 : 1 at 11 weeks and the cost of food per lb of bird would amount to 15d. For a similar food cost per lb the fat-supplemented diet would need to show a cumulative food conversion rate of 3.04 : 1 at the same age.

Light, and Egg Production

It is widely accepted among poultry-keepers that light stimulates egg production. The failure of egg production to show steady improvement through the summer is popularly held to be due to the lessening effect of any form of stimulation through the action of hormones. In a recent note on "Control of Seasonal Variation in the Egg Production of Hens" by J. C. D. HUTCHINSON (*Nature*, 1956, **177**, 795-6), the author described an experiment in which two groups of pullets were subjected to a 23½-hour and a 12-hour day length respectively from 8 weeks old until two months after laying had commenced. At the latter stage the birds receiving the longer daylight period were subjected to a decreasing period of artificial daylight until the 12-hour period was reached. This process has been called "devernalization" by the author. Egg production in both groups was approximately the same until devernalization commenced. But egg production of the devernalized group fell heavily after the daylight was reduced and did not recover for some months and moulting occurred. The production of this group after a day of 12 hours light was reached remained substantially below that of the control group which had continued to receive 12 hours daylight throughout. These results seem to show that egg production is not stimulated by the absolute day-length but by relative changes in the amount of light received. Further support is given to this view by the fact that a second devernalization after the birds had been in lay a year led to production almost ceasing.

A further interesting observation by Hutchinson related to the effect on production of temperature. Half of each group—the 12-hour group and the devernalized group—were subjected to temperature changes over 5 months to resemble autumn and winter conditions This had no effect on production.

Blood Groups in Poultry Breeding

For some time now a number of the larger poultry breeding organizations in the U.S.A. have been interested in the practical advantages of

using the rapidly expanding information available on blood groups in poultry. A great deal of work on this subject has been carried out by W. E. Briles and his colleagues at the Texas A. and M. College, U.S.A. Briefly, the theory advanced is that certain antigens are produced by certain lines or strains of birds, and these antigens are determined by certain blood group genes—probably linked genes. It appears from the work of Briles and his co-workers (W. E. BRILES, W. H. MCGIBEON and M. R. IRWIN, "Antigens in Chicken", *Genetics*, 1950, **35,** 633-52; W. E. BRILES and W. F. KRUEGER, "The Effect of Parental B Blood Group Genotypes on Hatchability and Livability in Leghorn Inbred Lines", *Poultry Sci.*, 1955, **34,** 1182; W. E. BRILES, "The Relationship between B Blood Group Genotypes and Adult Performance in Two White Leghorn Inbred Lines", *Poultry Sci.*, 1956, **35,** 1134-5) that if chicks heterozygous for this blood group type are produced they have a higher hatching rate and a lower early rate of mortality than those chicks which are homozygous for this blood group factor. Briles discusses at length methods of detecting lines with different blood group types and it seems clear that if this line of development is successfully pursued breeders may be supplied with another tool to increase hatchability and reduce mortality.

Pheasant Hybrids

The probability that certain strains of broilers have pheasant blood in their ancestry has more than once been advanced to explain the conformation of some broiler strains. In some countries such a claim has been used in advertizing table chickens. The work of W. E. Shaklee and C. W. Knox on the "Hybridization of the Pheasant and Fowl" (*Journ. Hered.*, 1954, **45,** 183-90) is therefore of interest for it gives precise information on this rather vexed subject. These workers mated male pheasants naturally and artificially with Cornish females. Only 3.48 per cent of the 1,409 eggs produced exhibited any embryonic development when incubated. Of this small number of fertile eggs only 6.12 per cent hatched, but only one female and two male hybrids survived this process. The birds appeared more like pheasant than fowl. No sexual activity was observed and subsequent autopsy showed infertile or degenerate gonads. The possibility of pheasants being used in broiler production seems, therefore, to be slight. R.C.

Commonwealth Agricultural Bureaux Publications

The Mulching of Vegetables*

A book devoted exclusively to the mulching of vegetables is a notable event, and Miss Rowe-Dutton has searched for and laboured skilfully to produce this readable and sensible review of the world literature.

**Patricia Rowe-Dutton.* The Mulching of Vegetables. Commonwealth Bureau of Horticulture and Plantation Crops, Tech. Comm. No. 24. 169 pp. Illus. (East Malling, Kent. Price 20s.)

Its international scope should not be overlooked, because although information on mulching in this country finds its place, it is only a fair place in the wider context. Indeed, close study shows how negligible the experimental work in Britain has been: out of a total of 370 references, this country only accounts for about 30, of which only 10 deal directly with research, and mostly not very recent.

No doubt the temperate climate and unpredictable weather of Britain as well as practical problems have had much to do with this neglect, but the belated national development of vegetable research may also have been a factor. Now that this gap is filled, this book may well promote a fresh examination of mulching practices.

It is necessary, therefore, to look further afield for research on mulching: to the hot and arid regions of the world where moisture conservation is vital; or to "continental" climes where extremes rule and frost protection in winter may be as important as other benefits in summer; or to the wind-swept steppe and savannah lands.

After an opening chapter on the purposes and problems of mulching, the main part of the book comprises eleven chapters dealing with the findings of research and practice with the principal vegetable crops; these include asparagus, brassicas, cucumbers, legumes, lettuce, onions and leeks, potatoes, roots, tomatoes and a few other crops. There is generally an introductory survey, followed by details of the effects of mulching on crop growth, yield, maturity, quality, and pest and disease incidence; the economic possibilities are considered, and the chapter closes with a brief summing-up of the main points and principles. The abstracts are generally adequate and practical without being overwhelming.

The author has rightly not attempted to reach a final conclusion on the advantages of particular methods and materials, but she has succeeded in bringing coherence to some intractable and often contradictory evidence which was uneven in quality of experiment and factual presentation, and emanated from a great range of countries, climates, cultural and economic conditions.

So far as English conditions are concerned, it is made clear that the mulching of potatoes, peas, onions, root crops or lettuce is not of much relevance—for reasons of climate or economics, or because there are better cultural alternatives. Nevertheless, with many other crops, there is at least something to prompt taking stock of practice or of the possibilities of mulching. Some newer materials may also have special uses in intensive production through influencing soil temperature.

This book can be commended as a stimulating review for the adviser and research worker, with much of practical interest to the grower.

R.T.P.

Provincial Notes

Controlled Grazing for Fattening Cattle and Sheep

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INCREASE OR MAINTENANCE OF PROFIT by higher output per acre has been the target now for several years. To achieve this with crops and cows was relatively straightforward if the farmer was interested, but with fattening cattle and sheep, tradition and lack of knowledge has made the risk seem greater than it really is.

Northumberland now carries one sheep to the acre in summer, but fifty years ago, with many farms worked on the Norfolk four-course rotation, the intensity of stocking was even higher. During the inter-war depression, with a much reduced tillage acreage, the emphasis was on grass fattening and deaths increased on sheep-sick grass; intensification was almost synonymous with disaster. Gradually a balance of numbers was established through experience, and these stocking rates in their turn became traditional.

Traditionally, cattle fattening pastures are but lightly stocked with sheep and the cattle left undisturbed in the same field until ready for the butcher.

Experiments on the intensive management of grass for beef and mutton production have not been carried out on anything like the same scale as for milk. The results of the former have been less clear-cut and decisive, and, possibly what is more important, there has not been the same all-out effort to help farmers to apply the newer techniques to this type of farming.

This article reviews the results of a sample of observation studies and experiments and describes local examples of their application on commercial farms.

Cattle

In 1952 a small N.A.A.S. observation study was begun on Craster South Farm, Northumberland [1], with the object of determining whether or not fattening cattle would settle and thrive under a system of strip grazing management. The field carried a rather "tathy" sward, being normally reserved for lambing. Results are given in Table 1.

Table 1

	1952 (13 weeks)			1953 (12 weeks)		
	No. of cattle	Average liveweight gain per head	Average liveweight gain per acre	No. of cattle	Average liveweight gain per head	Average liveweight gain per acre
		lb	*lb*		*lb*	*lb*
3 acres extensively grazed	4	182	243	4	147	196
3 acres strip grazed	5	168	280	6	140	280

In both years the cattle on the strip grazing appeared quite contented and settled immediately to the routine. During the first few weeks of both trials, the extensively grazed animals appeared to be making the best progress, but towards the end of the period those intensively managed were observed to be thriving best. Certainly, it was established that it was possible to fatten cattle satisfactorily behind an electric fence.

A second centre was established at Mousen Farm, Belford [2] in 1954, where Irish Hereford × heifers were rotationally grazed on four plots in a 17-acre field. On this system, too, the cattle made satisfactory liveweight gains. To keep the grass under control, one paddock was cut for silage—an illustration of the now widely recognized fact that intensive grassland management almost necessarily involves silage-making.

Critical experiments carried out by Hughes and Redford [3] at the Grassland Research Station in 1950 and 1951 produced similar results, and the authors concluded that:

(*a*) an increase in production is possible from pastures managed intensively under strip grazing, and

(*b*) the grazing of fattening stock under a strip grazing system is a satisfactory method of handling such cattle.

A further trial with cattle, carried out in 1953, and reported by Hughes [4], gave a liveweight gain per acre of 463 lb in addition to some conserved grass, and all the cattle graded out well.

Parkinson [5] has reported on several trials carried out in the north of Scotland, which confirm these findings. At three centres, the increased net return from the controlled over the unrestricted grazing ranged from £1.13 to £7.27 per acre.

Results from rotational grazing with mixed stocking are available from a trial carried out at Field Head, Northumberland [2] during 1953/54. A 17½-acre and a 25½-acre field were each divided into five paddocks. The results for the two years are summarized in Table 2.

Table 2

	Grazing Period	Total live-weight gain per acre	Additional Production	Average liveweight gain per week Cattle	Average liveweight gain per week Lambs
		lb		*lb*	*lb*
1953	20 weeks (cattle and lambs)	525	40 tons silage 4 „ hay	17.25	3.23
1954	17 weeks-cattle 14 weeks-lambs	418	10 „ „	15.65	3.85

The production figures should be read in conjunction with an estimated additional expenditure on fertilizers and fencing of £3 per acre per year compared with normal set stocking requirements.

Sheep

Intensive management of grassland for sheep presents an even more fascinating study than that of fattening cattle. There is no doubt that the problems involved are more numerous and more intricate. Experiments and observation studies have produced widely varying results.

Locally, a very interesting observation study has been going on since 1954 on the Hetton and Holborn Estates under the management of Mr. G. F. Ross [6]. The objectives were two-fold: first, to increase the weight of meat per acre, thus providing greater financial gain, and secondly, to reduce worm infestation, because fields lightly but continuously stocked with sheep tended to gather a high worm population. The alternatives appeared to be either rotational grazing, particularly in spring and early summer, or a reduction in the sheep stock.

In 1954, a 72-acre three-year-old Cockle Park-type ley, was dressed with 2 cwt "Nitro-Chalk" per acre in March and divided into six paddocks with sheep netting. The area was stocked with Half-bred ewes and cross lambs moved every three days and followed by Half-bred ewe hoggs two paddocks behind. The grass was chain harrowed after each grazing and topped when necessary, but in the main, growth was controlled by hoggs being added or withdrawn as necessary. The average rate of stocking was four ewes and twin lambs per acre; the maximum stocking of hoggs was six per acre.

Lambs averaged 20 lb live weight at the start of the grazing period and 80 lb at weaning when the rotational grazing was ended. No record was kept of ewe and ewe hogg weights, but both did well. With 280 ewes and twin lambs on 12 acres, some mis-mothering did occur, even though shepherding was carefully and quietly carried out. Some of the ewes tended to become uneasy by the end of each third day, possibly waiting for the move into the next paddock. Similar lambs on free range averaged 90 lb at weaning and had a better skin. Nevertheless, the system was economically sound. For approximately 13 weeks grazing the estimated gross return was £30 per acre. In the dry season of 1955, the gross return was £15 10s. per acre for eleven weeks and, with another lot of ewes and lambs, £17 10s. for thirteen weeks.

Also in 1955, a 35-acre fourth-year-ley was divided into three and stocked with Cheviot and Half-bred young sheep. Later, weaned lambs of the same breeds were introduced, and later still, Blackfaced lambs. The area was grazed with sheep only, the stocking rate over the whole period of 31 weeks averaging 7.5 sheep per acre. Total numbers ranged from 211 at the beginning (15th April) to a maximum of 387 (11 per acre) in July.

Each paddock was grazed for one week, then harrowed and rested for two weeks. Mowing was necessary on only two occasions; foot rot was less apparent than on extensively grazed fields; having plenty to eat, the sheep settled well. The estimated gross return was £37 per acre.

More precise information on the effect of rotational grazing on the worm burden is given by Thompson and Corner [7]. Over three years' trials, the average worm egg count of faeces samples varied little with the "extensive lambs", but the other group had higher counts with a five-day shift; equal counts with a three-day and lower with a two-day shift. Rotational grazing produced a considerably greater liveweight increase per acre in each year; the additional profit averaged £3.1 per acre, and deaths were fewer.

At Bridgets Farm, Hampshire [8], the liveweight gain in 1954 of lambs on paddocks was 0.51 lb a day compared with 0.63 lb for lambs grazed extensively. There was a clear indication that the anthelmintic treatment was inadequate for the lambs on the intensive system. In the following year, worm infestations generally were lower; more regular dosing was adopted and cattle were run over the plots during May and June for a week before the sheep were due to graze. The results then showed a striking uniformity of liveweight gain between the two groups.

On the other hand, at the Grassland Research Station [9] a two-day shift rotational grazing system resulted in inferior liveweight gains and body condition of lambs compared with results from a less intensive system.

An extension of the rotational grazing systems so far described was carried out by Dickson [10] at Cockle Park in 1955 and 1956 when rotational grazing was compared with rotational grazing plus forward creep grazing for the lambs. Some of the results obtained are given in Table 3.

Table 3

	Mean liveweight gain	Condition at weaning		Max. mean faecal worm egg counts
	lb per lamb	*No. Fat*	*No. Store*	*(eggs per gm faeces)*
1955				June 6
Rotational Grazing	50.00	38	26	1182
Rotational Creep Grazing	54.64	47	17	788
1956				May 24
Rotational Grazing	41.8	4	76	3249
Rotational Creep Grazing	52.8	38	42	1721

It is pointed out that the additional extra mean gain in 1956 of 11 lb per lamb in the creep grazing group represents an additional 55 lb dead weight per acre equivalent at 3s. per lb to £8 5s., whilst the costs of the two systems are virtually the same.

Application

So much for experimental work. The results show that cattle will fatten satisfactorily under intensive management and that higher liveweight output per acre can be achieved. With sheep, the results are much less definite and a great deal has yet to be learned particularly about the effect of intensive management on the incidence of worms. Nevertheless, there are indications that the rotational grazing technique may be of value.

On the other hand, it is a big step to translate such experimental techniques to farm practice. Fattening farms tend to be larger than the bulk of dairy holdings and output per acre less important. The dairyman is selling the produce of the cow whereas the feeder is selling the animal itself. Store cattle costs are a deterrent to intensive stocking, and the narrow margin between the buying and selling price does not encourage heavy expenditure on fertilizers. The saying "a sheep's worst enemy is another sheep" has been born out of bitter experience, and Spedding [11] clearly demonstrated the importance of even sub-clinical worm burdens on the rate of liveweight gain of lambs.

But necessity is the mother of invention. Rising feed and labour costs make it imperative to cut the winter feeding period to a minimum, and under a free marketing system it is obviously advantageous to sell fat stock at other than peak periods. Profits from sheep are stimulating

farmers to keep more and the only effective way to date of controlling Nematodirus is to concentrate lambs on clean ground during the danger period.

Perhaps the most obvious and straightforward example of how controlled grazing can be of benefit to cattle rearing and fattening is in the use of Italian ryegrass and the electric fence for early spring bite. Grass is always short in Northumberland at this time of year due to the cold North-East winds and the demands of the high sheep population.

For example, Mr. F. Walton at Flotterton has been able to cut down winter feed requirements this year by control grazing store cattle on Italian ryegrass during the day from 21st March, whereas the normal turning out time would be early May. On Mr. H. J. M. Chrisp's farm at Longbank, forward stores were turned out to strip graze Italian ryegrass on the 25th March, 1957. Numbers were quickly built up from 14 to 42 and by 31st May, 38 of these cattle were ready for the fat market, thus getting the advantage of higher prices at this time of year.

Last autumn, Mr. J. W. Frater, Goswick, was able to keep cattle cheaply beyond the autumn and Christmas selling peaks. He hained* and top dressed 18 acres of permanent grass which was stocked with 46 fattening cattle from 24th October. With the help of 4 lb home-grown cereals daily after Christmas all were sold Grade A in late January and early February.

On a Cheviot hill farm Messrs. T. Armstrong & Sons adopted a similar practice with a 21-acre reclaimed field. This provided grazing for 58 Galloway cows from 21st December to 20th February, admittedly in a very mild winter.

An example of intensive beef production on a small farm (37 acres) can be quoted from Mr. G. Crosby's Dyke Neuk Farm, near Morpeth, where last spring a 5½-acre field was direct reseeded with Italian ryegrass. Eighteen yearling suckler calves bought at an average price of £35 8s. were strip grazed from 26th May and sold fat at just over 7 cwt, leaving a gross margin of £38 10s. per acre.

There are possibilities too, even without using special purpose leys. Paddock grazing on a field scale has enabled Mr. F. West, Bowmont Hill, Cornhill, to carry a much bigger flock of ewes than would have been practicable on the traditional system. The farm of 430 acres carries 400 breeding ewes all the year round, and these are rotated round the grassland at a stocking rate of up to 6 ewes, with their lambs, per acre.

Influenced by the work at Cockle Park, two farmers have experimented in a small way with rotational creep grazing for lambs. At Flotterton, 32 Half-bred ewes with early February-born twins were put on to

* "hained": to clear of grazing stock.

10 acres of first year seeds in five paddocks. Grazing commenced on 21st March and numbers were increased to 45 ewes and twins on 30th March. As well as forward grazing, trough feed was available for the lambs at a cost of 2s. 9d. per head per week. Weekly liveweight gain from birth to sale averaged 10 lb per head. By the 3rd June, 76 lambs had been sold fat realizing an average price, inclusive of subsidy, of £9 5s. each.

At West Falloden, 10 acres of a five-year ley, split into five paddocks, were stocked with 40 ewes and 80 lambs on a rotational creep grazing basis without trough feed. Liveweight gains and body condition compared favourably with similar lambs extensively grazed on the remainder of the field at half the stocking rate.

Conclusions

Whether full scale rotational grazing and intensive grassland management will ever be a common feature of feeding farms, may be open to question.

There is no doubt, however, that its limited application has tremendous possibilities for the achievement of one or more of the following objectives:

(*a*) Producing meat at lower unit cost.

(*b*) Evening out the marketing of fatstock throughout the season.

(*c*) Producing more meat or releasing more land for tillage.

The examples quoted are perhaps sufficient to indicate that farmers are not only aware of the possibilities but, despite tradition and the gaps in present day knowledge, are making progress on an ever widening scale.

The situation is a challenge both to the research worker and the adviser.

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Some Experiences with Mobile Displays

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IT IS AXIOMATIC that the true adviser shall have the spirit of a missionary: it is therefore not surprising that some of us have devised missionary methods to meet those situations where the people have failed to come to us and we have perforce gone out to the people.

We found in north-east Staffordshire that neither the large-scale farm walk nor the meeting in the county town or similar place attracted many farmers from either the isolated farms or from the small family farms. They might attend an occasional winter discussion club meeting, or the N.F.U. branch meeting, but these events provided a quite inadequate opportunity for planned group activities to disseminate the wide scope of advisory information at our disposal. There were many reasons for their unwillingness to attend meetings. For example, if they left home the routine duties of the farm fell on an already overburdened wife; transport was also frequently a problem.

It became evident that advice would have to be taken to the farms, and thus the mobile display was devised for these potential audiences. Its main objects were:

- to bring to the farmer's attention the scope and value of the National Agricultural Advisory Service and the Agricultural Land Service,
- to demonstrate simple improved techniques, suitable for local application,
- to introduce the advisers as people.

The first of the mobile displays was mounted on a summer Saturday afternoon in the parish of Wetton, a small isolated village east of Leek. The area is 1,000 ft up, the farming is pastoral, and most of the farm homesteads are sited in the village. Three adjoining farms were used to demonstrate:

- controlled grazing with electric fencing,
- silage-making in a pit, with buckrake and green crop loader,
- culling poultry, using local birds.

The farmers of the surrounding parishes had all been invited by postcard. As they arrived they were informed of what was going on by a running commentary given by loud-speaker mounted on one of the vehicles. The whole outfit for the displays had been transported in two Land Rovers, except for the locally-borrowed buckrake, green crop loader, and poultry.

As had been hoped, the visitors were the farmers who had not usually attended our meetings. Not all of us were strangers to them, however, since the local District Officer was known to some, our specialist officer demonstrators known to others, and a few had met together at the winter discussion club. But all the visiting farmers seemed at their ease: they were among their own people, their own neighbours, and they showed no self-consciousness about asking questions. The occasion was undoubtedly a success.

Bigger and Better Displays

Inspired by this, we became more ambitious and set up a small Working Committee to devise and deal with bigger and better mobile displays the following year. We visited three new villages—Ellastone, Ipstones and Alstonefield, to demonstrate:

the bacon pig, correct feeding, weighing, demonstrated by the County Livestock Officer and a weighing machine. A weight-judging competition was held and results announced at the end of the day,

concrete mixing and use of simple building material, demonstrated by the Agricultural Land Service,

washing up dairy utensils,

culling and housing poultry,

care and maintenance of the mowing machine,

a selection of the Ministry's advisory publications, suitable for the locality.

We now toured with a small marquee, which housed the bookstall and the central control of the loud-speaker equipment. Before the demonstrations began a programme of attractive music was sent out over the loud speakers. Attendances at the demonstrations were good—from 40 to 100 farmers.

We were, it must be admitted, rather akin to a small travelling circus, except that we did not bring our animals: we borrowed them. But we did bring a four-ton lorry with trailer and two Land Rovers, and there was still the need for officers' cars to carry much miscellaneous equipment! We had provided an exhibit background for each demonstration, and each specialist spoke to his audience through the loud-speaker mounted on one of the Land Rovers, which moved from one demonstration to another. We gained much valuable experience in general organization and movement of material, with a resolve that in future we would carry less, and make it lighter and more portable!

Following the displays at Ipstones and Alstonefield we organized Farm Forums to take place in the evening at the local Village Institute, but we abandoned that idea: they made the day too long for everybody.

Experiment in the Lowlands

The next year we tackled five villages. For three of these we kept to the uplands of north-east Staffordshire—at Alton, Heaton, and Longnor—and as an experiment sited two in the lowland, mixed farming areas of Abbotts Bromley and Canwell Park, near Lichfield. Attendances were good in the uplands, but poor in the lowlands where probably the pull of urban amenities within easy reach is too great to allow this sort of display to make its full effect.

Rain, which we had escaped in earlier years, spoiled three occasions this year, and led us to tour a bigger marquee in future and exhibit the familiar injunction "If wet, the performance will take place under cover".

The displays followed the now familiar pattern, with a few new themes, including a demonstration based on farm management. We had, however, completely reorganized our equipment, streamlining and standardizing the backgrounds. We could now move in and erect a complete display in just over an hour, and dismantle it just as speedily.

Mobile displays, we became convinced, were valuable aids for the specialist using group methods in isolated and pastoral areas in upland districts.

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